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NOTES ON GERMAN AERODYNAMIC INFORMATION

by Gerald S. Kayton, NACA

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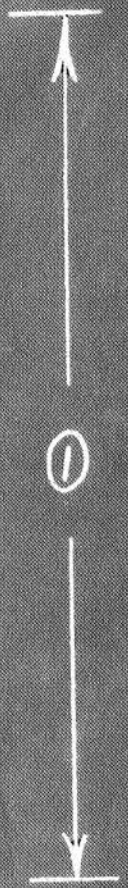
NOTES ON GERMAN AERODYNAMIC INFORMATION

ITEM No.

2715 Letter from Chief U. S. Naval Technical Mission in Europe, to Chief of Naval Operations - June 27, 1945



Through a method of air flow study by observation of cavitation bubble formation in a water tunnel (Dr. Reichter, Kaiser-Wilhelm Institute at Goettingen), Germans have made improvements on several designs. On the ME262, for example, a cavitation area on the upper wing surface was filled in with larger gas tanks, resulting in increased fuel capacity as well as increased critical speed. Jet engine installations, fairings, etc., have also been improved by this method.

Although pointing out that measurement of the contour of the constant pressure bubble is difficult and that the water flow represents a case of incompressible flow, the letter recommends work on this subject at the Taylor Model Basin as an aid in the development of high-speed aircraft.

2714 Notes on interview with Dr. Hermann at Kochell, June 15, 1945 (H. L. Dryden)

This note deals largely with high-speed testing equipment and technique but gives some particulars regarding several of the rocket projectiles and states that the aerodynamic work and trajectory computations had been completed for a rocket with a range of several thousand miles. This consisted of the V-2 rocket with small wings added and an additional rocket

boost of 100 tons starting thrust. The wings had a highly swept back leading edge and a swept forward trailing edge. The movement of the center of pressure with changing Mach number was kept small.

Regarding control at supersonic speeds,

"Hermann said that the normal type of trailing edge flap had been found to be better type of control at supersonic speeds than the spoiler type. Spoilers gave somewhat larger control moments at high supersonic speeds but the control coefficients fall off more rapidly at supersonic speeds than for the normal trailing edge flap type. It was, however, necessary to overbalance the controls at subsonic speeds in order that the hinge moment would not be excessive at supersonic speeds."

Report says supersonic but probably means subsonic.

2705 Technical Intelligence Report No. A-405 - June 1, 1945

It was learned from Messerschmitt flight research personnel that a landing (braking) parachute 5 - 7 meters in diameter and made up of strips with open spaces permitting the flow of air, was tested successfully in connection with the Arado No. 234.

Regarding the ME-163, these men cited the extremely small range, the high landing speed, and the handling difficulties at high speed as reasons for the failure of the airplane to prove practical.

2709 Technical Intelligence Report No. I-45 - June 30, 1945

This report deals entirely with electrical measuring equipment.

2708 Technical Intelligence Report No. I-44 - June 30, 1945

Discusses German propeller vibratory stress measurement technique which is found, in general, to be behind that in the United States. A list of German propeller experts and the type of work in which they have been engaged is included in this report.

Some development was apparently proceeding on wooden propellers with swept back blades to decrease tip speed losses. No details are given.

2600 Technical Intelligence Report No. I-12 - May 11, 1945

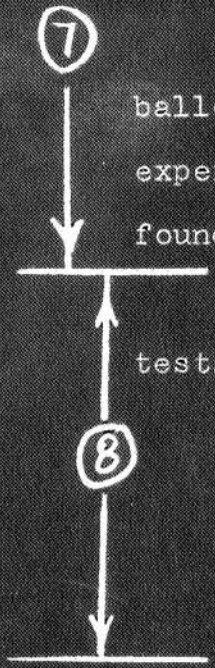
No aerodynamic information.

2598 Technical Intelligence Report No. P-3 - May 19, 1945

No aerodynamic information (hydraulic systems, shock absorbers, etc.).

2670 Technical Intelligence Report No. E-15

Dr. Guenther revealed that work had been done toward improving the poor stability of kites intended to replace barrage



balloons. Mathematical calculations were completed and experimental investigation had just started. Box kites were found to be the most stable but many others were being tested.

Dr. Guenther also informed the interrogator that wind-tunnel tests had been conducted at Berlin-Gatow on:

(a) Lift and drag on cables

(b) Aerodynamic characteristics of various fuselage shapes

(c) Stability at high altitudes

(d) Smoke flow studies.

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*6930 Nontechnical Intelligence Report No. E-16 - June 23, 1945

No aerodynamic information.

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*6930 Nontechnical Intelligence Report No. E-12 - June 18, 1945

No aerodynamic information.

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*6930 Nontechnical Intelligence Report No. E-13 - June 17, 1945

No aerodynamic information.

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*6930 Nontechnical Intelligence Report No. E-17 - June 18, 1945

No aerodynamic information.

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*6930 Nontechnical Intelligence Report No. E-18 - July 17, 1945

No aerodynamic information.

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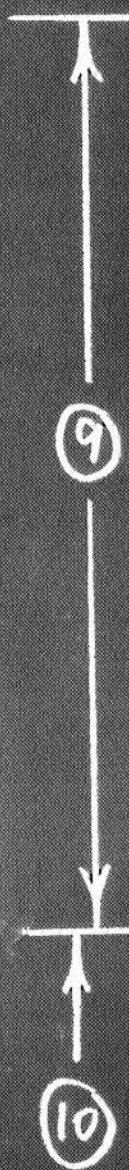
*These reports deal entirely with meteorological equipment.

2668 Technical Intelligence Report No. E-12 - May 31, 1945
(Written by F. W. Geiger of Curtiss-Wright, Buffalo)

1. It was learned from Braun that control surfaces on the F-55 rocket-propelled missile (designed for investigation of the transonic region) were of NACA 0009 section. Low drag sections for such small thickness were not considered necessary. The "wings" on this missile are swept back, with vertical fins and rudders attached at the tips with a slight toe-in. They are so located to place them out of the fuselage wake and permit the use of smaller areas.

Curves of drag coefficient versus Mach number were obtained by a statistical method of fairing theodolite film records. Drag coefficient was found to begin rising at about $M = 0.8$ and was still rising slightly at $M = 1.25$ (top speed for the F-55). At this point, the drag coefficient was about 2-1/2 times its low-speed value.

2. "Experiments carried out here showed that at low aspect ratio (two) the effect of sweepback was almost negligible. In F.B. 1846 it is reported, however that as far as the critical



10

Mach number is concerned (defined in terms of the rise in drag coefficient) a wing with aspect ratio near unity is equivalent to a wing aspect ratio six with 35 degrees of sweepback."

3. In Geiger's opinion, the people at L.F.A. know less about wind-tunnel interference than we in the United States. No work had apparently been done there "to test (in the wind tunnel) the validity of the wind-tunnel results." Busemann of L.F.A., however, offered a partial explanation as to why the flow in open-throat subsonic wind tunnels is unsteady at speeds near M = 1.0. He stated (and demonstrated by photographs) that disturbances originating on the boundary of the free jet travel slowly up-stream, causing irregularities in the flow.

11

The report contains a discussion of design and flow problems in supersonic wind tunnels. It also contains a list of reports (published and unpublished), motion-picture films, photographs, and slides discovered during a search through L.F.A. buildings.

12

4. Mr. Geiger summarizes his other findings as follows:

The characteristics method in supersonic flow.

Dr. Guderley has worked extensively with the characteristics method. He has written several papers on the subject and is at present writing a general paper on the method, with particular emphasis on the axially symmetric flow. His method could be applied, for example, to the problem of finding the form of a projectile with the minimum wave resistance (neglecting the wake). He believes that the nose should be flat (over a small area) and that this should be followed by an arc of constant pressure. The form he believes can be calculated by the characteristics method.

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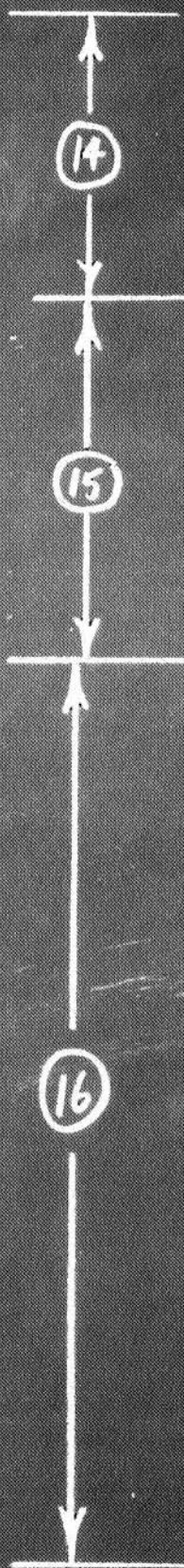


Mixed subsonic and supersonic flow.

Guderley has been working on the Chaplygin method through the asymptotic representation of the hypergeometric functions. He intended to sum the series, adding the difference between the exact hypergeometric function and the asymptotic form as a correction; but, I believe, he had not up to the present carried this out.

The Busemann Biplane.

Busemann stated that his interest in the Busemann Biplane was purely theoretical and that as far as he knew no work was being done on it here. (He was not correct because Schlieren photographs of the flow past this biplane were found in the office of Eggink, who is no longer here.) It had been studied at Guidonia; but the results were rather disappointing in that the effect of the biplane in reducing the drag was small. (We have copies of a report on this subject in the States.)

Aerodynamics of the Athodyd.

1. A cold athodyd was testing in one of the supersonic tunnels here. It was found that in any axially symmetric compression in an athodyd without a centrally lying body one always obtains a normal shock wave with a resulting decrease in efficiency. It is therefore necessary to have such a centrally lying body which is designed so as to obtain a compression initially away from the axis instead of towards it. If a suitable body is used, no normal shock is obtained, but rather a series of oblique shock waves with considerably less total energy loss.

2. There must also be such a central body (Spitze) at the entrance to a duct in order that one does not obtain a normal shock wave ahead of the duct. In the case of the duct without the Spitz there are two solutions involving shock waves, both of which are stable. One gives a normal shock wave in front of the duct. The other gives oblique shock waves starting from the rim of the duct. If a body is slowly accelerated to supersonic velocity, it is the normal shock wave which is obtained. Regarding this, it was found that the flow with the normal shock wave could be changed over to the flow without the normal shock wave merely by inserting a wire into the wave and allowing the wire to vibrate.

3. It should be remembered that the story may be completely different for a hot athodyd in supersonic flow.

2669 Technical Intelligence Report No. E-11 - May 29, 1945

17

This report gives a detailed description of apparatus and technique for the study of two-dimensional flow characteristics by the interference method as employed at the L.F.A. Research Center.

2706 Technical Intelligence Report No. I-40 - June 29, 1945

(Interrogation of Prof. Busemann, May 25, 1945)

18

This report contains a discussion of ram-jet and rocket development tests and a further discussion of supersonic wind-tunnel design supplementing the discussion in Technical Intelligence Report No. E-12.

It also contains the following summary of findings by W/C Smelt:

19

Entry design for Lorin ducts (reported by W/C Smelt).

(a) For the entry to a supersonic duct, a reversed Laval nozzle is required. This can exist, with only a small shock at the throat; but there is another, far more stable arrangement with a normal shock ahead of the entry and subsonic flow over the whole length of the diffuser. The first low-loss arrangement is only possible over a very narrow range of Mach numbers, but it can be induced to occur by "Stirring up" with a thin wire in entry or alternatively by changing the throat area in sympathy with the Mach numbers. There is an amusing film of this in building A-11 (35mm size). A similar problem arised in recovery of pressure in a supersonic wind tunnel.

(b) Axially symmetrical ducts have the disadvantage that the shocks coming from the wall concentrate on the axis to produce a powerful normal shock. To avoid this Busemann recommends a central spike ahead of the entry to force the

(19)

first shock outwards instead of inwards. He also indicated how to take advantage of lower loss through a series of shock waves instead of a single one, by design to produce shock reflection from central body to outer shell and back alternately. This is the advantage for very high Mach numbers (greater than 2) and can be achieved only for a small range of Mach numbers.

(c) Busemann said that the leading edge of the outer body should have an "angle of attack", with respect to the axis, such that the outer side lines up with (is tangent to) the shock wave coming off the point of the inner body.

(d) Oswatitch of AVA has written several reports on this subject; viz, "Berichte" 1005, 1010/1, 1010/2 (not "Forschungsberichte", but issued by ZWB in the same manner).

2707 Technical Intelligence Report No. I-42 - May 27, 1945

(Interrogation of Dr. Knackstedt, L.F.A.)

(20)

This report contains short summaries of results of two ram-jet investigations. One of these installations was tested for Focke-Wulf. Dr. Pabst (Focke-Wulf) planned as one use for the ram-jet, a ram-jet propelled three-blade propeller for aircraft, the ram jet being placed at the propeller tips. This propeller assembly had not yet been tested.

2593 Technical Intelligence Report No. I-10 - May 21, 1945

Interviews with Dr. Kurt Tank, Otto Pabst, and Hans Multhopp (Focke-Wulf)

By Kármán, Dryden, Schaires, and Colonel Dane.

(21)

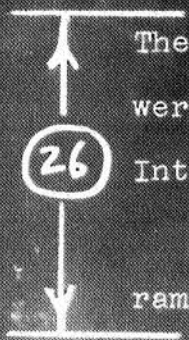
Tank, who was Technical Director for Focke-Wulf, stated that although wood (used in recent construction as a substitute

material) permitted the production of a smooth surface for laminar flow wings, he did not use laminar flow sections because he did not think a sufficiently smooth surface could be maintained. His fighters had a parasite drag area (C_DA) of about 4.1 square feet, or with a typical value of A = 186 square feet, a drag coefficient of about 0.022. He used air entry at the fuselage nose as best. He knew of wing intakes used in United States but had not used them.

Regarding high-speed flight tests, Tank said he personally had flown the FW-190 over 600 miles per hour in dives from 33,000 feet. He encountered large stick forces but no buffeting, noted some aileron disturbances (over-balance at high speeds), and some condensation shock on the wing. He had heard that the tailless ME-163 had trouble in dives, tending to nose over sharply.

The latest Focke-Wulf project was the FW-183 driven by a similar turbo jet engine (3100 pounds thrust). It had 40° of sweepback, a 10 percent thick wing (average), a weight of 10,000 pounds (4000 pounds of which was fuel), and a wing loading of 44 pounds per square foot. It was intended for high speed of about 590 miles per hour at 20,000 feet. The service ceiling was to have been 47,000 feet.

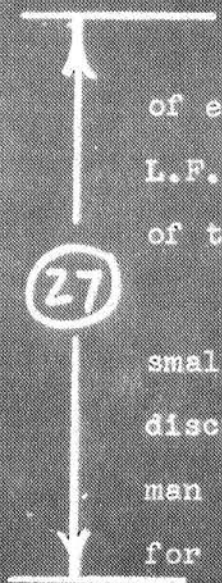
"Another recent design studied by Focke-Wulf was a new type with three slowly rotating wings. The aircraft was launched with its axis vertical, the wheels being in the tail structure. The fuselage was fixed. After being started by auxiliary means, the wings were to be driven by ram jet motors (Lorin Antrieb) at the wing tips. The angle of attack of the axis required when in level flight was only twice the angle of attack of an ordinary wing. The diameter was 10.5m. The weight was to be 5 tons. ...."



The ram jet motors were developed and built by Tank. They were tested on a model by Busemann at L.F.A. (see Technical Intelligence Report No. I-42).

The remainder of the report contains details of the ram jet design.

5375 Technical Intelligence Report No. I-35



This report described L.F.A. methods of roll stabilizations of experimental rockets in flight tests and also summarizes L.F.A. knowledge of the effects of rocket jet on the operation of the ratio in the rocket.

The roll stabilization ~~must~~ was provided, in most instances, by small "~~flow~~ full-on or ~~flow~~ full-off" ailerons controlled by gyro equipment discussed in some detail in the report. Kerris (the L.F.A. man interviewed) had no experience with the use of spoilers for aileron control.

2711 Report of Carleton Kemper (ALSOS mission) - June 22, 1945 on the Ju-262 jet fighter.

(Returned to Library because page 2 is missing.)

2658 Technical Intelligence Report No. I-41 - June 13, 1945

This report is a brief discussion of the work of Correll (L.F.A.) on the stability of beam-guided missiles. This work (for yaw and pitch) is reported in F.B. 1847 and V.M. 2084. A

28

similar analysis for aileron control is reported in F.B. 1892 (parts 1 through 9).

5340 Technical Intelligence Report No. I-50 - June 7, 1945

This report contains notes on interrogation of men at Gottingen with particular regard to aircraft propellers, including high-speed effects on airfoil characteristics, propeller test data, and test methods.

29

Drs. Walchner and Ludweig had done work on the determinations of best profile contours for propellers on high-speed Naval vessels by calculations of the streamline flow of water over the propellers. Tests of the resulting propeller show high efficiency and good correlation with calculations. Further calculations were being made to determine the best plan form shapes.

Walchner, who was in charge of subsonic study at Gottingen, stated that practically all of his work during the past 5 years had been on bullet testing (M = 1.2 to 2.6) no airfoil testing had been done in that range because it was believed that the results would be inaccurate.

30

". . . It is felt that with the small tunnels available, shock waves set up on the model strike the wall and reflect back on the model, substantially affecting the drag. They recommend that the ratio of model to tunnel be such that the reflected shock wave definitely clear the model. This condition also exists at subsonic Mach No., where shock waves are developed. Walchner would not offer an estimate of the probable airfoil characteristics between M = 0.85 and 1.2. Dr. Ludweig estimated that while

the ratio of the drag coefficient at low Mach Nos. (approximately 0.5) to the peak of the drag curve varies considerably with profile and lift coefficient, a value of 5 might be possible for good profiles at low lift coefficients. He stated that the closed throat tunnel gives drag substantially higher than the free air condition due to wall and channel conditions. He also stated that open throat tunnels give drag values below free flight conditions. His special recent work has been the calculation of the corrections to both types of tunnel in the Mach No. range up to 0.9. At the M No. the open throat drag value is approximately 2/3 the closed throat drag. His calculations indicate the free air drag is closer to the open throat condition, and the correction applied to both types of tunnel data still leave a discrepancy of approximately 10%. Ludweig and Walchner feel that at Mach No. 1, the flow conditions are so unstable that values will fluctuate greatly. Also, Ludweig's method of correcting for tunnel characteristics is not applicable in the supersonic range."

(30)

Some attention was apparently being given the possibility of using rotating-arm equipment to obtain data in the Mach number range of 0.9 and up, in order to eliminate tunnel wall effects.

(31)

Ludweig and Hansen stated that the lift-drag ratios of the very low aspect ratio wings were suprisingly good at high Mach numbers at the range of 1.2 and above; definitely better than the high aspect ratio wings. They also found the test data to indicate that the cross sectional area of an airfoil or a body of revolution plays a greater part in the drag than it does at subsonic velocities.

(32)

The writers (A. Dickey and L. H. Enos) were of the opinion that systematic propeller testing at Gottingen appeared well behind American work.

(33)

The report includes a description of the large elliptical tunnel. It contains references to further descriptive material as well as reference to reports on the afore-mentioned bullet testing.

(34)

2597 Technical Intelligence Report No. I-14 - May 24, 1945

This report summarizes information obtained from Mr. Voigt, Director of New Designs, Messerschmitt, Oberammergau. Messerschmitt had apparently encountered difficulty in the nature of longitudinal trim changes above critical Mach number (nose-heavy trim changes for critical conditions on free wing surfaces, nose-up changes for critical conditions on lower surfaces) similar to those encountered in United States flight test. A particular local critical area on the ME-262 free surface was corrected by a fairing developed following cavitation studies of a model in the water tunnel at Gottingen.

Current production airplanes used considerable aerodynamic balance to avoid prohibitive stick forces, but three methods of boost being considered:

"a. Using a sealed balance, similar to our NACA design, but vented to a point further aft on the running surface to get higher unit pressures for more effective boost.

"b. Using hydraulic or electric servo systems.

"c. Using Flettner servo tabs, in which case a small control surface was direct-connected to the cockpit controls to provide "feel", with a second larger movable surface with the servo tabs next to it. It was planned to provide a disconnect lever on the control stick to disconnect and lock the direct-connected surfaces at very high speeds. Mr. Voigt thought speeds of Mach number 0.9 would be possible with satisfactory control with this system, but was a little worried about flutter at speeds above Mach number 0.75 in the Flettner system."

With regard to balancing of control forces, it appears that Messerschmitt had the same difficulty in obtaining a high

degree of aerodynamic balance and in avoiding sensitivity of closely balanced surfaces through small variations as United States manufacturers.

Messerschmitt engineers were trying to raise the critical speed of their design, principally by the use of exaggerated sweepback. The ME-163, however, was given its large sweepback originally not for this reason, but because it had no horizontal tail.

The report contains an explanation of the German sweepback theory developed from the work of Betz, Busemann, and Gothert. This theory is included, along with more advanced work on the subject, in a recent NACA report by R. T. Jones.

It appears that the question of the desirability of tailless airplanes is no more settled in Germany than it is in the United States.

The following is quoted from the report with regard to airfoils:

"The question of airfoils was discussed, and Mr. Voigt stated that up to 1939 the NACA Airfoil data was used here almost exclusively. The use of airfoils with no camber at all for their wind tunnel work has shown that zero camber airfoils will hold their low drag coefficients up to 0.75 Mach no. from C_L = 0 up to C_L = 0.4, while with 2 percent camber the drag is higher all over the range and critical flow starts as low as Mach no. 0.35 at C_L = 0.4.

"No reflexed airfoils are used on new designs except on tailless aircraft.

"Most sections have the max. ordinate at 40 percent chord, but some of the newer designs are moving it back to 50 percent and in some cases for very high speeds to 60 percent.

42

"They are just beginning to use the cusped tail on some designs and Mr. Voigt thinks it is better.

"Generally nose radii are somewhat sharper than NACA standard - usually 3/4 of NACA ordinates give max. C_L. Here the "Ellipse theory" was generally used for determining the nose radius.

"Generally they are fussy about airfoil contours and sufficiently thick skin to maintain smooth surfaces in flight."

1800 Technical Intelligence Report No. I-56 - July 2, 1945

43

This report contains rather complete descriptions of the Doblhoff, Focke, and Flettner helicopters based on interrogations of Messrs. Doblhoff, Focke, and Flettner and on inspection and demonstration of some of the machines. The rotors on the Doblhoff machine were driven at the tips by burning and expulsion of a gasoline-air mixture piped to the tips. Power was initially supplied by a 135 horsepower conventional engine. For future designs, however, Doblhoff hoped to use "stuttering" athodyds mounted on the blade tips, eliminating the conventional power plant entirely. A small fixed-pitch propeller was used to provide a blast of air over the tail surfaces during hovering for directional control. A large fixed-pitch propeller could be clutched in for forward speed. The machine then acted as a pusher autogyro.

2689 Technical Intelligence Report No. I-54 - May 30, 1945

Interrogation of Multhopp

44 An extension to the work of Scheubel explaining the effects of elastic structures on stability was carried out at D.V.L. by theory and qualitative flight tests.

45 A German code for evaluation of flight stability and control had been written (by Doetsch, D.V.L.) and was being circulated for comment. Although only meager details are given in the report, Multhopp claims to be able to reproduce much of the code from notes.

"Multhopp was questioned concerning the problems of sweptback wings. Stalling troubles were encountered, and could be minimized by using low tapers, thick tip and proper airfoils. Washout was not much help. Work on airfoil stalling characteristics was done by Liebe at DVL. Tests were both flight and wind tunnel. Later Liebe worked at Pragan. Some work was also done at Gottingen. The airfoil nose shape was very important.

46 "Multhopp said that stalling moments were encountered near the stall with swept wings, either forward or backward. This is due to the early separation of the aftmost part of the wing. The effect is primarily one of wing moments.

"Multhopp said that tip slots were not very satisfactory. On the Me-262 they open about an inch at high speed due to deflections.

47 "Considerable work has been done by Junkers at Dessau on swept forward wing in conjunction with their JU-287. Both Junkers and Heinkel have done extensive work in their own wind tunnels on the problem of fitting nacelles to a sweptback wing. Some work was also done at Gottingen. Most of this data was published through ZWB. Both the Heinkel and Junkers tests were at high speed. Truckenbold did the work at Junkers. The only satisfactory nacelles were those with the nose at 50% wing chord.

48 "Both Junkers and Heinkel have run tests to determine the effects of jets on the fuselage when the jet exit is forward of the end of the fuselage.

49 "Multhopp was questioned concerning propeller tip speed losses. He said that model tests have been run at DVL and Gottingen (Seifert) to study these losses and the effects of propeller sweepback."

The report contains a list of the men in Germany most familiar with airplane stability and control.

2657 Technical Intelligence Report No. I-27

No aerodynamic information.

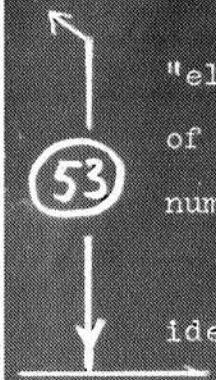
2712 Technical Intelligence Report No. I-61 - January 24, 1945

This report contains a description of the He-280-V-7 twin-rocket fighter, and a summary of results of flight tests in which the He-280-V-7, less the two rocket engines, was flown as a glider. Although some tests were made in dives up to 580 miles per hour, the majority of the tests were studies at or near the stall.

> "During these flight tests it was noticed that the qualities of the air current near the stall are influenced in a fundamental manner by the distribution of the ratio of the diameter of the leading edge to the thickness of the wing along the span. This aerodynamic value was varied in several ways, but these tests were not finished."

2656 Technical Intelligence Report No. N-4 - May 20, 1945

This report contains details (chiefly concerning the rocket motor, fuels, etc.) of the "Great Enzian" E-4 controlled anti-aircraft missile, a tailless craft with sweptback wings of approximately 13-foot span. Control is achieved by means of



"elevon" type surfaces. The E-4 was designed for a Mach number of 0.9, but an advanced model E-5 was contemplated for a Mach number of 2.0.

Three other types of projected controlled missiles are identified but only meager details are given.

2591 Technical Intelligence Report No. I-2b - May 25, 1945

This is a translation of a statement by Dr. Herbert Wagner completely absolving himself from blame in connection with the development of the V-1 missile.

It is of aerodynamic interest only in that Dr. Wagner tacitly stresses the need for aileron control rather than rudder control for accurate direction of a missile intended to hit an exact target.

3001 Technical Intelligence Report No. I-5 - May 12, 1945

This report contains a description of a "doughnut" type free-piston engine developed by Lutz at the Goering Institute.

2590 Technical Intelligence Report No. P-17 - May 28, 1945

This report contains information on propellers, obtained at the V.D.M. works at Frankfurt-on-Main. The information is chiefly concerned with production.

(56) "The Germans had data on the NACA 16-series profiles but claim that wind-tunnel tests showed no improvement over profiles they were using." (Dr. Kramer, V.D.M. Chief Aerodynamicist, is referred to for further data on the German profiles.)

Reference is made to two reports, the first of which is believed to contain the method used for propeller performance calculation:

(57) 1. Uber Naherungsweise Luftschrauben-Rechnungen Mittelz Pularen. von Karl N. Kramer. Jahrbuch 1941 dur deutschen Luftfahrtforschung (1404-1418).
On approximate computations for propellers by means of polars.

2. "Segriffs Bestimmungen fur Vortriebsluftschrauben" Heft 1 der Baurorschriefften fur Huftschrauben, Ausgabe Januar 1940.

(58) Apparently the development of dual rotation propellers had been given low priority because engine powers had not become high enough so that dual rotation was considered necessary. Some work had been done using propellers for dive brakes, but no details are given.

59

2659 Technical Intelligence Report No. A-411 - June 3, 1945

This report contains a description of B.M.W. jet-propulsion units and information on allied subjects.

60

2633 Technical Intelligence Report No. I-25 - May 9, 1945

This is a report on the interrogation of Dr. Blenck of L.F.A. and appears very similar in scope to Technical Intelligence Report No. I-17.

> "Blenck said that he did not believe that the wind tunnel was the place to obtain aerodynamic data for speeds in the vicinity of a Mach number of one. The flight test method developed here appears to be the solution of this problem."

61

Mr. F. W. Geiger adds the following notes on the Blenck interview:

Wind-Tunnel Interference

"Prof. Blenck is not satisfied with the present methods of supporting models in wind tunnels, which include vertical supports of the type commonly used in the U.S., supports at an angle with the tunnel axis and supports along that axis in which there is no support in the plane of the model. All are in some ways objectionable in that they lead to unknown errors.

He believes that corrections for incompressible flow corrected for compressibility a La Glauert can be used with safety for at least up to the critical Mach numbers (I agree).

He thinks that wind tunnel data cannot be applied to flight in the range 0.8 to 1.3m and that one must resort here to flight tests.

Athodyd (ramjet) tests.

1. Plans were set up for testing athodyds in wind tunnel.

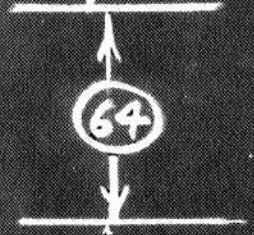
2. The plans were never carried out because of the end of the war."

62

5340 Technical Intelligence Report No. I-17 - May 9, 1945

This report contains information obtained from Dr. Blenck, Director of the Herman Goering Institute, Brannschweig.

"Blenck was asked to briefly outline the accomplishments of the aerodynamics division during the war. He said that in the early days of the institute research of a fundamental character was conducted. The work gradually changed character and the large wind tunnel was finally used almost entirely for tests for industry. He described the development of a new optical method by Zobel in which interference and schlieren pictures of a flow could be taken simultaneously at the rate of 1,000 pictures per second. The method had been applied to obtain aerodynamic data useful in flutter calculations. The model was a wing extending entirely across the working section of a small wind tunnel (A model of the large wind tunnel). The wing had two degrees of freedom, lateral and torsional. The pressure distribution on the oscillating wing (amplitude about 3 cm) could be determined from the photographic records of interference fringes. A comparison of the experimental and theoretical results had not been completed. Blenck did not believe that there had been much progress in flutter theory."



"Schlichting had done theoretical work on boundary layer control by suction and pressure. Only little experimental work had been done on this subject at the L.F.A. The project had been pushed by Schlichting. Blenck himself felt that there was some promise of a considerable advance, but the aircraft industry has little hope of a useful result."

"Theoretical work had been done by von Baranoff and Guderlei on blocking corrections in wind tunnels."

The paper contains notes on the organization of German aerodynamic research facilities and personnel.

1001 Technical Intelligence Report No. I-11 - May 21, 1945

Horten Brothers were constructing a flying wind-tunnel - an entrance cone, working section and diffuser to be carried by a six-engined tailless airplane at about 220 miles per hour. A speed of 310 to 340 miles per hour was expected in the test section.

"This wind tunnel would be turbulence-free. Hence it would be suitable for tests of laminar flow airfoils and other high-speed tests."

This report contains some details of tailless airplanes projected by the Horten Brothers.

"The sweepback has been 32° on some designs, 42° on others. The dihedral has varied from 0° to 3°. The directional stability is only about one fourth that of a normal airplane. The resulting long period oscillation after a disturbance is easily controlled by the pilot, and gives very pleasant handling characteristics."

"They (The FAGZ) also worked on the braking of aircraft by means of parachutes. For this they developed a special type of parachute (Bänderfallischim - ribbon parachute) consisting of crossed ribbons forming a grid with holes for the escape of air. This opened very gently and did not oscillate. Without this feature the braking of airplanes would not have been successful. The development took place between 1932 and 1937."

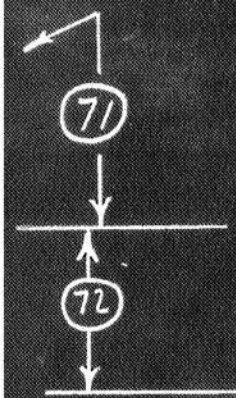
"The diameter of the parachute for braking was often greater than the span. A Ju 34 of wing area 435 ft.^{2} had been landed with a parachute 29.5 feet in diameter fastened to the tail. In the Ju 88 the landing distance over a 65.6 obstacle was reduced from 3610 feet to 1640 feet."

5375 Henschel 298/1 - Technical Intelligence Report No. I-62
June 22, 1945

This report contains information on the Hs 298 air-to-air rocket missile designed for a maximum speed of 260 meters/second (582 miles per hour) for a brief period.

"The wing was tapered 2 to 1 and had squared tips. The airfoil section was the NACA 0012, modified so that the maximum thickness occurred at 40 percent chord. At the tips this maximum thickness was moved back to 50 percent chord."

"Fixed vertical tail surfaces were provided at the tips of the horizontal tail. Moveable control surfaces were provided for control of roll and pitch only. These control surfaces were novel in that they consisted of narrow slats located at the trailing edge of the main surface and broadside to the airstream. The width of these slats was from 2.5 to 3 percent of the wing chord. In the neutral position the slat was evenly divided by the trailing edge. With the



control hard over, the slat was moved so that its whole width was to one side of the trailing edge. Hesky claimed this type of control has no greater drag than the normal Flettner type because of the thickness of the boundary layer at the trailing edge. The aileron slats were 12 cm. long, and the elevator slat extended the full length of the horizontal tail."

"A simple two-axis electric automatic pilot provided stabilization. Radio remote control by the pilot of the launching airplane operated through this automatic pilot to the control surfaces."

1001 Heinkel 162 A-1 - Technical Intelligence Report No. A-342 May 8, 1945

This report contains a description of the jet-propelled Heinkel He162 fighter. Except for (a), the jet unit mounted above the fuselage as the V-1 bomb, and (b), the provision for horizontal trim by ±5° deflection of the entire empennage about a hinge in the fuselage, the He162 appears to have been an entirely conventional airplane.

The information in the report does not suggest any unusual aerodynamic knowledge.

6200 Non-Technical Intelligence Report No. E-5 - July 11, 1945

Report on photographic equipment. No aerodynamic information.

6970 Non-Technical Intelligence Report No. E-9 - June 3, 1945,

Medical report. No aerodynamic information.

6970 Non-Technical Intelligence Report No. E-6 - June 5, 1945

Medical report. No aerodynamic information.

6970 Non-Technical Intelligence Report No. E-7 - June 6, 1945

Medical report. No aerodynamic information.

6970 Non-Technical Intelligence Report No. E-8 - June 12, 1945

Medical report. No aerodynamic information.

6970 Non-Technical Intelligence Report No. E-10 - June 12, 1945

Medical report. No aerodynamic information.

2603 Technical Intelligence Report No. I-26 - June 1, 1945

Interrogation of Prof. Busemann

74 In the subsonic tunnels, streamlined bodies with and without sweepback were studied; also studied were "porous bodies of rotation to allow air to pass through them (not successful)."

Pfeilflugel or "arrow wings," or "sweepback."

75 "Experiments in which the wings of the projectile were of square shape (average chord equals the semi-span) were carried out. It was found that here sweepback had no appreciable effect on the critical Mach number (defined as the Mach number at which the drag coefficient rises).

76 "However, experiments with large span have shown that for a wing alone and up to 45° sweepback the simplified theory is checked sufficiently accurately by experiments (two-dimensional theory). Lippisch of Messerschmitt carried out experiments here on wings and reached a critical Mach number around 0.85 to 0.90 instead of M = 0.75 for the non-sweptback wing.

"No three-dimensional theory is available for effect of sweepback on Mach number of critical flow.

"In the supersonic tunnels the following were being studied:
a. The rise of pressure in reversed Laval nozzels at high Mach number.
b. Instability of flow through diffusers (shock wave elimination) for athodyds."

"Regain of pressure in the athodyd and in the reversed Laval nozzel and flow instability.

77 "It was found that in any axially symmetric compression without a central body one always gets a normal shock wave with a resulting decrease in efficiency. It is therefore necessary to have such a central body which is designed so as to obtain a compression initially away from the axis instead of towards it. If a suitably long central body is used, no normal shock is obtained, but rather, a series of oblique shock waves with considerably less total energy loss.

"The same applies to an entrance to a duct in supersonic flow. Otherwise there will always be normal shock wave just ahead of the duct. In the case of the duct there are two solutions involving shock waves, both of which are stable. When such an internal pointed body is present, there is only one solution.

The report also contains a discussion of wind tunnel interference and super-wind tunnels similar to that in Technical Intelligence Report No. E-12.

78 "Busemann stated that Helmholz had believed that transition from laminar to turbulent flow in the boundary layer was responsible for fixing the position of compression shock, but that he had given up the idea when he became convinced that such a transition meant a reduction in the thickness of the boundary layer (in supersonic flow?)."

Note contradiction - Items 78 and S-21

2644 Technical Intelligence Report No. A-395 - June 23, 1945

This report contains specifications for the Focke-Wulf Model 183, complete with drawings and performance curves. It also contains a list of references (Focke-Wulf reports) of interest, as for example:

File No.	Contents
30/109	Aerodynamics data for FW183
H/19	Technical Report on several jet fighters, February 1945
XB/140	Design requirements of jet fighters and comparison of some models, August 1944

2635 Technical Intelligence Report No. A-403 - May 20, 1945

This report contains rough sketches and comments on five possible designs contemplated by Messerschmitt for an advanced single-engine jet fighter. It also contains Messerschmitt ideas on relative merits of jet and conventional propulsion for military airplanes.

> "They have not done much on this bullet shape of wing for supersonic speeds, feeling that the large degree of sweep-ba offered a better solution. They are also of the opinion, based on laboratory tests, that the nose of the fuselage need not be extremely sharp for supersonic speeds."

Also contained in the report are notes on a rocket assist unit and on the Me 262.

2602 Technical Intelligence Report No. I-31 - May 10, 1945

Interrogation of Dr. Ing. Theodor Zobel, Dept. Head of L.F.A. (by von Karman, Tsien, Wattendorf, Dryden, Schairer, Stever, Norris, Simon)

Zobel has developed a technique for flow analysis by an interferometer (described in "A report of the Deutsche Akademic der Luftfahrtforschung") which, he claims, gives a sensitivity of the order of 1000 times better than that of the Schlieren method. To reduce difficulties arising from air pulsations and mechanical vibrations, to which the method is sensitive, a new small tunnel was built at L.F.A.

83

Spoilers

"The major contribution on this subject was the provision of an air duct from the stagnation point on an airfoil to the point just aft of the spoiler. This feature greatly reduces the time lag between the raising of the spoiler and the effect of this on the lift of the airfoil. The spoiler here considered is hinged. When folded down, it is flush with the airfoil surface, and closes the duct opening, the hinge then being on the upstream side of the spoiler flap. This spoiler, with the duct, is on the upper side of the airfoil, located about 10 percent of the chord length from the leading edge. A similar spoiler, but one having no duct, is also located on the lower side of the airfoil, about 40 to 50 percent aft of the leading edge. The duct width is about 1 percent of the chord length.

84

These spoilers are used primarily for ailerons, in place of moveable ailerons.

Tests of various shapes of spoiler, e.g., notched, screen arrangements, saw-tooth, etc. were made, but the simple solid flat-plate type was chosen as the best."

NOTE: This work is reported in F.B.1304.

With regard to the effect of sweepback in increasing the Mach numbers at which rapid drag increase begins, Zobel states that "This advantage can be obtained with a central fuselage, but not with nacelles placed between the fuselage and wing tips." He states further that stability and lift coefficient at landing are undesirably reduced.

85

The report recommends further study on the interferometer technique, including possible removal of the L.F.A. equipment out of Germany. It also suggests further questioning regarding the relative merits of the flap-type spoiler and other types.

2599 Technical Intelligence Report No. I-18 - May 14, 1945

This report contains information regarding jet engine and gas turbine design (Heinkel-Hirth, B.M.W.).

2710 Report (HZB/216) of Col. Bogert, Alsos Mission, on visit to Göttingen

This report deals chiefly with descriptions of the laboratory equipment. It does, however, mention the presence of highly swept-back (45° - 60°) wings and several wings of low aspect ratio and trapezoidal planform.

2713 Technical Intelligence Report No. I-51 - May 25, 1945

No aerodynamic information.

5001 Technical Intelligence Report No. I-43

No aerodynamic information.

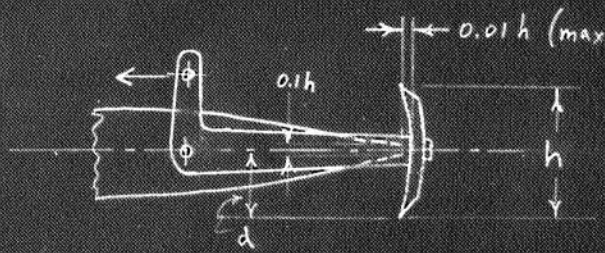
5001 Technical Intelligence Report No. I-39

No aerodynamic information.

2534 Report on Interview with Dr. Wagner by Aerodynamics and Hydrodynamics Branch on 26 May 1945. - June 7, 1945

(Interview chiefly concerned HS-117, HS-293, and HS-294 missiles.)

On these missiles, a spoiler-type control was used, consisting of a small spoiler installed behind the surface trailing edge. "Vertical motion (of the spoiler) provided lift forces for the desired control." The arrangement is shown in the following sketch (figure 1 of the report).



d = deflection

$\left(\frac{2d}{h}\right)$ = deflection parameter

Dr. Wagner claims small aerodynamic lag, small control forces, and construction simplicity as outstanding features of the arrangement. When this type of control was substituted for a conventional flap-type aileron on the HS-293, the lag was reduced from 0.5 seconds to approximately 0.1 seconds. (Full control deflection was obtained in approximately 0.02 seconds with a magnetic actuating mechanism.) Characteristics of the spoiler control were investigated in wind-tunnel tests of both 12 percent thick and 5 percent thick airfoils, with practically identical results. (The report includes curves showing section lift coefficient plotted against spoiler height, h, in percent of the wing chord, and also section lift

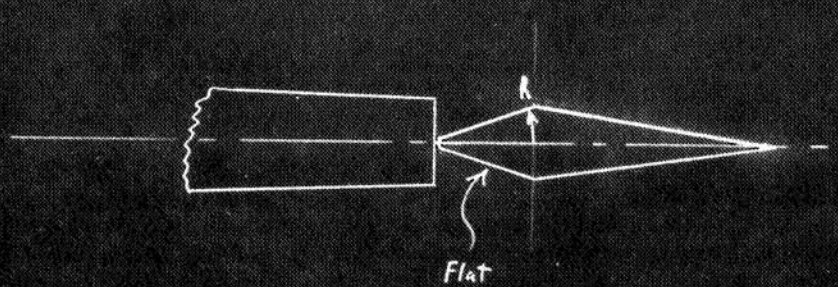
89

coefficient plotted against angle of attack for zero, full up, and full-down deflection of a spoiler with h/c=0.022. For h/c values up to 0.03, the variation of lift with h/c appears essentially linear, but Wagner states that the maximum practical value of h/c was limited to 0.025 because of erratic spoiler action above that value. (Theoretical consideration of a very small trailing-edge flap deflected 90° indicated lift proportional to flap height.) Wagner claims that increments due to partial spoiler deflection were linearly proportional to the deflection.

"The drag of the control in the neutral position corresponds to a coefficient value of approximately 0.4 to 0.7 based on frontal area of the spoiler and the air speed of the missile."

The HS-117, with a leading-edge sweepback of 35°, longitudinal stability at high lift coefficients was poor, and the maximum lift attainable was thus limited.

"On conventional flap-type control surfaces the effects of compressibility were avoided by using an overhanging balance with flat sides so that there was no change in the curvature presented to the passing air, Figure 5."



"Dr. Wagner stated that they had found that inaccuracies of wing trailing edge had a rather large influence on aerodynamic characteristics. To avoid these effects it was customary to employ magnesium castings for the portion of the wing structur aft of 70 percent chord. Particular emphasis was placed on obtaining wings with smooth surfaces and accurate profiles."

93 "In regard to the stability characteristics incorporated in the missiles, it was clearly stated that the aim was to provide ample static stability, longitudinally and directionally, coupled with neutral lateral stability, i.e., zero effective dihedral. It was thus possible to control the missile using only elevators and ailerons. Dr. Wagner's remarks would lead one to believe that the stability and controllability thus attained were entirely satisfactory."

94 Tail surfaces in most instances were of 12 percent thickness ratio. On one missile, HS-293, a 7 percent section was used. This was found less desirable "because of poor lift characteristics."

"The position of maximum thickness on the wings was about 30 percent chord in the case of the HS-293 and about 40 percent chord for HS-117."

2634 Technical Intelligence Report No. I-21 - June 10, 1945

(Interrogation of Woldemar Voigt, Messerschmitt)

Me 163C

95 "The flaps on the underside 50 percent point were mainly a drag control."

Me 262

96 "This version had two (2) prototypes, the first with 35 degrees sweepback, 25 m2 area, the second with 45 degrees sweepback, 28 m2 area."

"Further work was done on fairing between wing and nacelles. This work was done primarily in the water tunnel at Gottingen, and some interesting results were obtained. It was claimed that as a result of these tests a blister was developed which carried an additional 200 lb. on each wing and which simultaneously reduced the drag on the engine nacelle."

Me 1101

97 (Single-engine jet fighter similar to Me 262 - 35° to 45° sweepback, depending on test results)

"Eight (8%) percent thickness at root and 12 percent at tip. This resulted in nearly constant thickness spanwise and gave rectangular flaps and slot sections."

"It was noted that the boundary layer tends to follow the sweep of the wing with the result that very poor characteristics resulted when the wing was swept forward 35 to 45 degrees. This was because all the boundary layer came down to the center section and then impinged on the tail, giving poor stability."

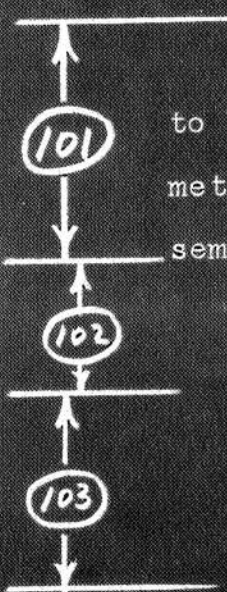
"Another note is that, in general, good agreement between tunnel and flight tests had been obtained except in a few notable cases where structural deflections had caused serious deviations. Herr Voigt cited an example in which the stability had been markedly improved by changing the stabilizer setting one degree and adjusting the trim tabs. Theoretically, this gives no improvement, but in this case the preloading presumably changed the deflection characteristics, which in turn brought the airplane stability back to theoretical."

Mel111 and Mel112

"Mel111 and Mel112 - These were flying wing versions of a single engine fighter. These studies were undertaken for comparison of tailed and tailess airplanes designed for the same mission."

2594 Technical Intelligence Report No. I-33 - June 18, 1945

(Interrogation of Dr. Braun)



The Rheintochter, a rocket-driver flak projectile designed to be launched from the ground to a speed of about 450-500 meters/second (1000-1120 miles per hour), had "six fins resembling tail fins, but mounted further forward."

"The rudders are near the nose, as Braun thinks this is preferable for supersonic flight."

"The Feuerlillie F-55 "has only a horizontal swept back stabilizer with vertical stabilizers mounted on tips with a slight toe-in. The location of the vertical fin was chosen because of launching difficulties if they are placed on the fuselage, and because they are beyond the wake of the wing and the fuselage and can, as a result, be made smaller."

104

"The wing section is the NACA 0009. It is not considered to be the best possible. Braun remarked that if a thinner section had been required a laminar flow section could have been used to advantage. With this I agree."

(NOTE: Preceding note written by Mr. Geiger.)

105

"The 'toe-in' of the vertical fins was intended to eliminate the 'Flat-spot' in the curve of sideward-force versus yaw-angle, otherwise obtained near zero degree angle. This remedy does not work, however, in all such cases, (as is commonly believed) but did work here."

106

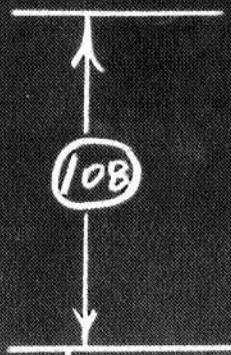
The Hs-298, a subsonic air-to-air missile (M-0.7 -0.8) has a "spoiler arrangement for elevator or speed control at the trailing edge of the stabilizer (or wing). It has a velocity meter for controlling (the spoiler). This was a bulbons object the drag of which determined the position of the spoiler."

2727 Technical Intelligence Report No. A-475 - May 24, 1945

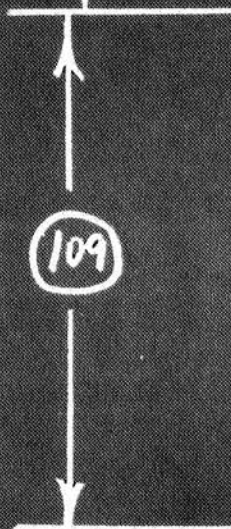
This report contains notes obtained from Dr. Lippisch on the Project 13A Jager, tailless twin rocket propelled wing for supersonic speeds.

107

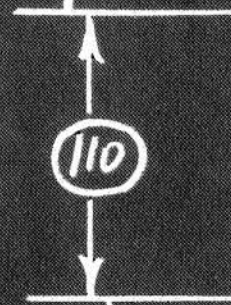
"General Description: The wing plan is one of swept back leading edge coming to an inclusive angle of approximately 60°, and a trailing edge that tapers forward to form an angle of about 80° with the ship's center line. Airfoil sections appear to be of symmetrical, laminar-flow design with filleting held to a minimum. The fuselage is a straight line dorsal and fin, sloping back at an estimated 30° with the thrust line. This structure is also of symmetrical airfoil contour, and houses the cockpit about midway up the dorsal fin with no breaks in the entering edge of the fin to cause disturbed air flow. Twin rocket tubes of the compressorless Lorin type are installed outboard of the fuselage fin on either side, and are completely contained within the wing contour."



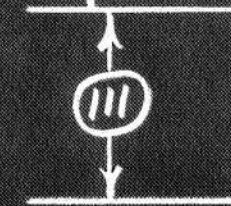
"Control and Control Surfaces: The rudder pedals and rudder surfaces installations are conventional with single push and pull tubes to torque arm. The stick is connected to the combination aileron and elevator surfaces through a gear assembly which allows equal deflection of the surfaces as elevators and reverse throw when used as ailerons. A trailing edge flap and flow control surface at the inboard trailing edge may be trimmed from the cockpit, and the upper and lower sections are interconnected by cranks and actuating rods."



"Internal Air Ducts and Control: The inlet duct for ram air for internal cooling and trailing edge flow control extends forward of the apex of the leading edges much in the manner of a pitot tube. Air is ducted into the leading edges, where it is controlled up over an internal passage between an inner and outer skin. This flow apparently exists only in the center section, where temperatures must be maintained for protection of the fuel cells by providing insulation from heat generated by skin friction on the upper surface of wing. The air passes out at the trailing edge in a flat sheet and splits over the trailing edge of the flap. Ducts carry part of the ram flow from the upper duct area down through to the lower section of the trailing edge flaps without passing between a double skin passage as in the case of the upper surface of the wing."



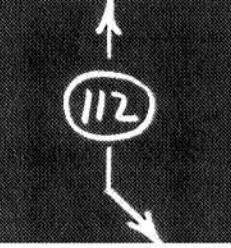
"Rocket Engine Installation: Two Lorin type rocket tubes are installed on each side of the centralfin and fuselage. These units extend through the wing from the leading edge to the trailing edge in a straight line. It has been indicated that these engines are self supporting on ram air without a compressor after a speed of 80 m/sec. has been reached. No provision for accelerating and take-off rockets appears in the general plan form of the model."



"Conclusion: Evidence supports the assertion that this aircraft design was being thoroughly studied for control of critical aerodynamic phenomena at supersonic speeds. A scale model was tested in a smoke wind tunnel at an approximate Mach number of 2.6."

2592 Technical Intelligence Report No. I-28 - May 12, 1945

Interrogation of Prof. Eike, L.F.A.



A. Flutter tests.

"The first flutter models were wood, but recent models are made of plastic, polyvenylchloride. Three or four flutter

models were tested in the last three years. A complete model of the JU-288 was tested in 1941. A basic wing model with two engines was tested for Messerschmitt. Also a model of the "Volksjaeger" HE 162, scale about 1:1.5."

B. Static aerodynamic tests.

"For static aerodynamic tests a basic study was underway on four basic wing shapes, without fuselage, with low-speed conventional airfoil sections. (Observation of models indicates profile to be high-speed sections). The shapes consisted of zero sweep-back, moderate sweepback, high sweepback, and sweepforward. The study included evaluating split-flaps and leading edge slats both inboard and outboard. The work on this project was just started. A large wing section, for high Reynold's number, chord of approximately 15 feet, with a Schlichting profile F0015-38-60 was tested. The laminar flow benefits were not apparent in the 8 M tunnel."

2596 Technical Intelligence Report No. I-38 - May 28, 1945

This report contains a list of twelve papers which may or may not be of interest. Titles are being translated from German.

2632 Technical Intelligence Report No. I-36 - May 28, 1945

Interrogation of Prof. Busemann for the purpose of identifying Schlieren photographs and motion pictures.

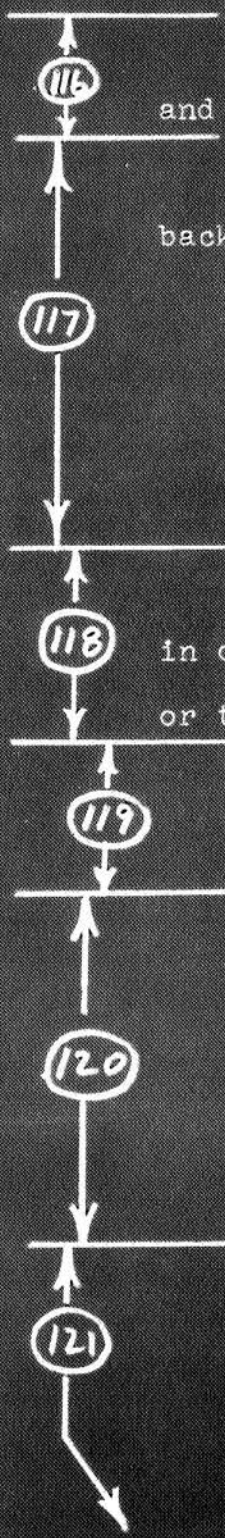
Some of the moving picture films show the flow past a cold athodyd at supersonic speeds showing:

"The effect of a wedge not a cone along the tunnel axis on the shock wave ahead of the athodyd, particularly demonstrating that it is possible to have at a given Mach number the shock wave at one angle on one side of the wedge and the shock wave at another angle on the other side of the wedge (as predicted theoretically by Busemann).

The effect produced by a vibrating wire introduced into the normal shock wave ahead of the athodyd in changing the flow from one with this shockwave present to one in which it is not present and in which one obtains only oblique shock waves (at the entrance to the duct)."

2595 Technical Intelligence Report No. I-37 - June 18, 1945

Interrogation of Gerhard Braun regarding L.F.A. Flak Rockets development.



This report contains data on the "Feuerlillie" (F-25, F-55) and "Hecht" missiles.

Gothert (DVL) wrote an F.B. report on drop tests of swept-back wind models from 36,000 feet.

"Another method using a radio transmitter, on the model, and measurements of force on the wing (to give drag, lift, moment), also speed, was under development at DVL, but had not yet been used.

Rheinmetall-Borsig made flight tests to get lift data by using a helical trajectory, the amplitude of this helix being a measure of the lift, without need for differentiation."

F-25, F-55 needed roll stabilization because they had "wings" in one plane, whereas some of the others had wings in two (90°) or three (60°) planes.

Control Surfaces

No rudder was provided on F-25 or F-55, yaw control being obtained from aileron control. This is in accordance with remote control considerations considered in F.B. 1847.

On F-55 the half of the trailing edge, of the wing, nearest the fuselage, was not movable, but eventually was to have been made movable for use as an elevator. The outer half of the trailing edge was always used as an aileron.

Two vertical fins (for F-55 mounted on the wing tips, and for F-25 on the tips of the "horizontal" stabilizer-fin) were used, the position being chosen to keep them out of the wake of the body. The tail-less arrangement used for F-55 puts the stabilizer and aileron surfaces on the wing, so that there is no wake to affect them.

For super-sonic speeds Braun would choose a rudder at the nose, as in "Rheintochter", to get a favorable moment arm, in view of the c.g. of the missile being so far aft, due to the motor weight. Parts of a small scale model of

121

F-55 of this type, for supersonic wind tunnel tests, are in building B-1.

At speeds close to sonic, Braun said he would expect difficulties from conventional aileron control, due to large hinge moments, and to lower efficiency from compressibility burbel.

122

The "Leistenruder", or "Trailing-edge spoiler rudder" arrangement for ailerons and elevator, is used on Hs-298 for this reason. This was to have been tried eventually on F-55 also. It is particularly convenient also for use with automatic control, because it has negligible time lag. The increase in drag coefficient it introduces is of the order of 0.05, Braun estimated.

Wing Profile

The profile NACA 0009, with maximum thickness 30 percent of chord back from the leading edge, was used on F-55. This is so thin that the shape is not of much importance. Maximum thickness at the 40 percent point would probably be a little better.

123

For supersonic missiles, Braun would like to try these alternative profiles, viz:

(a) A bi-convex profile with slight rounded nose, assuming that the angle of attack in the sub-sonic region would not exceed 5 degrees.
(b) Profile NACA 0009.
(c) Profile NACA 0009 with maximum thickness further aft."

124

The effect of aspect ratio on lift or wings at supersonic speeds near sonic is not known, Braun said; at very high speeds it is known to be negligible."

125

Braun recommends booster installed alongside of main body rather than behind to avoid longitudinal stability difficulties encountered in German tests.

Body Shape

126

A tangent ogive having a 10-caliber radius head was chosen for the nose shape of F-55 because this was the shape recommended by the Peenemunde people for supersonic rockets, on the basis of their experience.

Effect of the Jet on Aerodynamics of the Body

"The rate of change of mass of the rocket must be considered when considering longitudinal stability just after launching; i.e., the yawing moment equals $\frac{d(Id\alpha/dt)}{dt}$, not merely $I(d^2\alpha/dt^2)$. A damping effect, or increased angular inertia, is therefore obtained by the flow in the jet, particularly at the start.

"The effect of a pitch or yaw change may cause a small further addition to the damping by its effect on the boundary layer.

(127)

"The form drag is increased by the presence of the jet, as regards the effect of pressure distribution over the body surface. Tests of pressure distribution showed this increase to be 70 percent for the condition tested. However, the scope of the tests was rather limited. They were made at Aachen on a model of "V-2". The effect would decrease if the ratio of jet diameter to maximum body diameter were decreased.

Angular Inertia of the Engine Propellant

"It was customary to assume that inertia of the liquid propellant in the tanks, as towards angular motion, was the same as if it were a solid body, but Braun admitted that swirling of the liquid might considerably reduce the effective moment of inertia, especially for rolling motion.

"They used no baffles inside the tanks to prevent this swirling effect.

Ideas for Future Improvements

"Use of the Jet to produce suction of the boundary layer of the rocket body, and thus reduce drag, was an idea Braun mentioned as a refinement to be considered in the future."

2.702 This document is a three-view drawing of a German high-speed jet-propelled airplane design with sweptback wings and tail surfaces.

(128)

"Air inlets for jet engines at wing-fuselage junction, at about 80 percent chord location, apparently for the purpose of sucking in flow separated due to shock for transonic as well as for supersonic wing."

2703 Deutsche Forschungsanstalt fur Segelflug ("Ernst Udet" Institut fur Fluyzeugbau) - Report DFS-346 (HS-8)

"Design of a Test Airplane for Investigation of Transonic Phenomena"

129

This is a report, in German, including description, specifications, aerodynamic data, three-view drawings, etc., for the subject design, which appears to be the Henschel HS-8.

2601 Technical Intelligence Report No. I-55 - May 28, 1945

Interview with Dr. Lippisch

Regarding his tailless design DFS 39 (forerunner of Me-163)

130

"When asked why he did not use spoilers for lateral control, Lippisch said that spoilers on swept-back wings give trim difficulties unless the spoilers are on the center of gravity. Trailing edge flaps also give trim difficulties. Therefore Lippisch in some designs had used flaps ahead of the trailing edge. These are less effective than trailing edge flaps but give less moment change."

131

The Me 163 originated in a request to use the Walter rocket engine (cold system) in "an airplane whose development was most advanced as regards flying qualities, and the aerodynamic design of the DFS 39 was selected. The triangular fuselage cross section on Me 163A was intended to give the same lift distribution across the fuselage as on the wing."

132

". . . . A central rudder was used. The end plates on the wings or turned-down tips were discarded for fear of wing flutter, since the rudders were back of the elastic axis of the wing. The central rudder gave improved control characteristics, for the aerodynamic coefficients of the end plate rudders changed with lift distribution. The rudder could not be omitted because of the destabilizing effect of the fuselage nose extending outside the wing contour."

133

"Lippisch stated that it was very easy to obtain longitudinal stability in tailless aircraft, but the first and most difficult requirement was to secure directional stability about a vertical axis. To avoid reversal of the stick force at the stall, the wing

must be designed to stall at the center first. To achieve this fixed flots were used at the wing tips, first adjustable, and later fixed. A special form of fixed slot was developed by Lippisch which had low drag in the normal flight condition. It was designed to have equal pressures at the two ends of the slot and hence no flow through the slot in the normal flight attitude. This section with slot gave a smooth polar curve. For aspect ratio 5, the lift was maintained to an angle of attack of 30° and the maximum lift coefficient was 2.2. The airplane with slot length equal to 40 percent of the semispan could not be spun. With crossed controls, the airplane merely sideslipped. The outer half of the slot was then closed, leaving the slot open from the 60 percent semispan to the 80 percent semispan position measured from the center. The airplane could then be spun in a perfectly controlled manner.

"Lippisch contends that high-speed aircraft must be designed for a low lift coefficient, and hence must use a low wing loading; otherwise the drag is excessive.

"The thickness of the wing was 14 percent at the center, and 9 percent at the tip. The thickness distribution was an NACA one but the center line shape was Lippisch's own development to give stable wing sections, the trailing edge being turned up. The sections used were of relatively small camber. In the earlier design (300 Km/hr) a washout of 6° had been used but in the Me 163A stability was secured by the use of stable airfoil sections

"At 1005 Km/hr at the test altitude the Mach number was 0.85 and compression shock occurred at the wing tip. The lift actually became negative at the tip and caused a sudden tendency to dive. The tendency was less at high altitude."

Two auxiliary rockets were used for assisted take-off (Me 163B).

"To provide for control if one launching rocket failed, rudders were used working in the boundary layer of the exhaust stream. The rudders were of steel. The carbon rudder within the jet was developed at Peenemunde specifically for V-2."

Brief descriptions of the P-11 and P-13, two rather advanced Lippisch designs, are included in this report. The P-11, designed for 650 mph, had a symmetrical, untwisted wing "of stable section" with a leading edge swept-back 40° and a straight trailing edge. A negative dihedral of 1 1/2° was used.

"The wing profile was nearly the same as that of the Mustang. The maximum thickness was at 37 percent from the leading edge at the center and somewhat further forward at the outer sections. No slots were used.

"Lippisch considers the ram jet as suitable for ordinary speeds and claims to have made flying models at speeds of 35 Km/hr. He said that most theories treated only the thermodynamic aspects and that it was necessary to consider the aero-thermodynamic aspects. In this connection he called attention to the large effect of the outer shape. He thinks the front part should be shaped like a wing operating at an angle of attack and that the principal part of the thrust arises from the suction over the outer forward part of the surface. Ringleb collaborated with him and developed new theoretical methods for computing aero-thermodynamic flows."

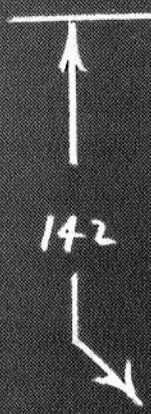
1101.3 122 Technical Intelligence Report No. I-20, June 1, 1945

This report covers the interrogation of a Mr. Nurnberg on methods of flutter calculations. Although the methods employed by Nurnberg's group (which appears to be part of a Messerschmitt organization) may differ in details from those employed by various U. S. companies, the discussion does not seem to reveal any knowledge of theory more advanced than that possessed in this country. Two limits of possible advanced knowledge, however, are contained as follows:

"A new compressibility theory has been developed by Dietz at DVL in Berlin, but this is too complicated to apply to routine analysis and is apparently not too well understood.

"The effect of a sweepback of 23°, according to calculations, reduced flutter speed by 15 percent. The effect was mechanical, the aerodynamic effects of sweepback not being considered. By this is meant principally that bending of the wing changes its angle of attack as a result of sweepback."

2681 Lilienthal Gesellschaft Bericht 156 - October, 1942



This is a collection of the following papers (in German) and the discussion following their presentation:

Gothert, B., "Profile Measurements in the DVL High-Speed Wind Tunnel."

Zobel, Th., "On Some Results with the Interference Method in the High-Speed Tunnel of the LFA."

Gothert, B., "High-Speed Measurements on a Swept-Back Wing ($\varphi = 35°$)."

2747 Technical Intelligence Report No. E-19 - July 7, 1945

143

"Tests were conducted to determine the possibility of using gliders to assist takeoff and climb of powered aircraft. Flight tests were conducted using a small sport plane in combination with an Nu 17 glider. After a towed takeoff, the glider pulled up over the powered aircraft using its lift to add to that of the powered aircraft."

The report gives further details on this project.

144

"c. One of the gliders built by the subject group, the D-30 "Cirrus", had the unusually large aspect ratio of 33.6. A diagram of this machine is shown in Fig. 3. The dihedral of the outer wings of the D-30 glider could be adjusted so that tests could be carried out on the effect of variation of the dihedral angle on lateral stability."

145

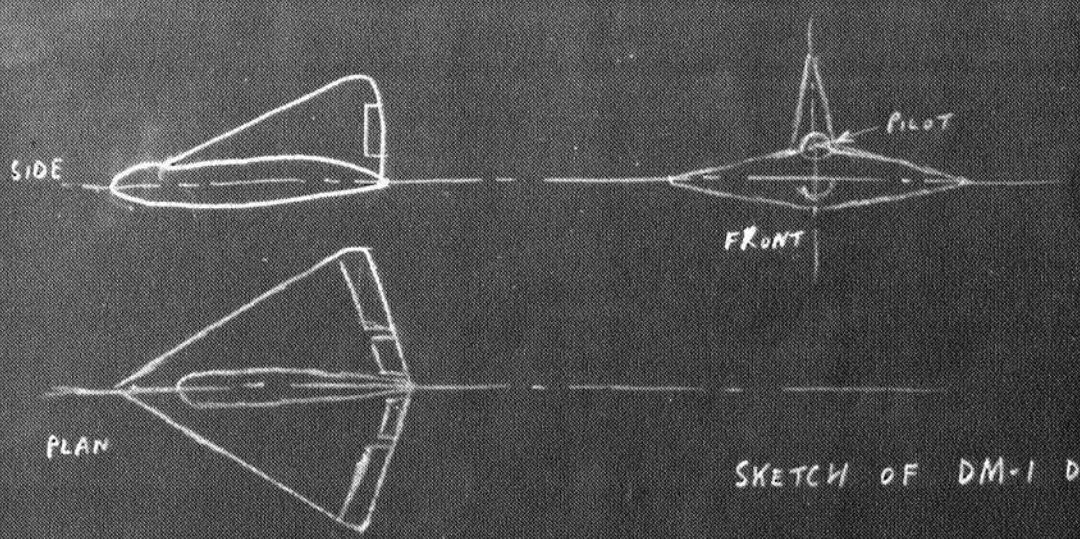
The report contains details of a tailless, low aspect ratio aircraft (rocket driven) designed for supersonic speeds at high altitudes as well as successful flight at the necessary low speeds. This design called the DM-1 and somewhat similar to the (Lippisch) P-13, has an aspect ratio of 2.0, a leading-edge sweepback of 60°, and a slightly swept forward trailing edge. "The wing is not twisted and without dihedral. The profile is a symmetrical elliptical one, found by calculation, to which the rudders were fixed afterwards. The distribution of pressure of the main profile is such that in passing the velocity of sound the compression shock at the leading edge and at the trailing edge of the profile occurs at the same time and therefore there is no moment change. The greatest thickness of the wing profile is 16.6% at 45% of the chord length in reference to the main profile (15% in reference to total length),

see Sketch p. 44

146

146 the greatest thickness of the vertical tail profile 19.2% at 45% chord length in reference to the main profile (17.5% in reference to the total length).

147 The outer control surfaces have a normal symmetrical profile with trailing edge. The greatest thickness is in 25% of the rudder chord, the torsion axis in 27% . They are elevator and aileron at the same time. The inner rudders are normal camber rudders for trim compensation."



SKETCH OF DM-1 DESIGN

2672

148 This is a folder containing photostatic prints of photographs of the ~~Domier~~ Dornier Do-335, a night fighter with a tractor propeller at the nose and a pusher propeller aft of horizontal and vertical tail surfaces at the rear of the fuselage.

C1113 Schelde/1 Identification No. 506

No aerodynamic information.

6800 Germany - 1944-1 Identification No. 64

Report by General Olmeda and Colonel Eula (Italy) on visit to Germany (1941)

S-1

(P. 40) The Flight Section at Goettingen had tested (prior to October 1941) two airplanes equipped with boundary-layer intake devices.

"One of them is a tourist monoplane, in the fuselage of which is placed a motor which activates a ventilator. Intake is effected through holes drilled into the rear wall of the casing which constitutes the wing structure. The holes are of dimensions increasing from the center to the tip of the wing. Intake is through a fissure which has been made between the wing and the curvature fin.

"The maximum Cp noted in flight, with the device in action, is between 2.5 and 3.

"A similar device has been applied to a high-wing Fieseler-Storch monoplane. Because of the larger wing surface, the ventilator is more powerful (50 HP) and is activated by the motor of the plane by menas of a transmission made of conic couples. The installation is very cumbersome and takes up the entire fuselage behind the pilot's cabin; two big tubes connect the ventilator with the interior of the wing casing; the air flows out the sides of the fuselage. The airplane, without a fixed forward fissure, reaches, with the device in action, a maximum Cp between 2 and 2.5.

Regarding work on elimination of "porpoising" (at Goettingen):

S-2

(P. 52) "The results of the research can be summarized in the statement that, if the angles of attack assumed by the hydroplane are put on a graph as a function of the velocity, two curves are defined, which represent, respectively, the lower and upper limits of the angles, outside of which no 'porpoising' takes place. If, however, the angle is comprised within these limits, the hydroplane oscillates more or less violently on take-off and on landing. When the angle is small the oscillations are particularly dangerous.

S-2

"The phenomenon of 'porpoising' depends essentially on the assembly of the empennage and, contrary to that which has been supposed, is altogether independent of the position of the baricenter.

"On the basis of this finding, the D.V.L. has been able to furnish the industry with precise norms for avoiding this defect; and has also studied and built a unitary float of the D.V.L. type, which has been universally adopted by German builders."

S-3

In a meeting to discuss collaboration between German and Italian aeronautical research bodies,

(P. 72) "Dr. Baeumker said that it is necessary for Europe to try to keep pace with American developments in the field of aeronautical research. In Europe, unfortunately, the war has blocked the development of facilities, which goes on rapidly and elaborately in the United States. It is necessary that Europe be not outdone, because that would be dangerous, and we would find that within a few years American aeronautics was well in the lead. From this aspect, too, collaboration seems desirable."

S-4

S-109 Identification No. 432, April 21, 1945

Contains meager information on several German rocket projectiles.

5375-159 Identification No. 481, February 6, 1945

Development of Special Missiles in Germany

S-5

Further details on rocket missiles - contains good overall listing of names and types, and fairly complete specifications for "Wasserfall," "Rheintochter," "Enzian," and "Schmetterling" missiles.

S-105 Identification No. 529

Interviews with Dr. Busemann May 9, 1945 and May 13, 1945.

S-6

"Busemann stated that most of his ideas about supersonic flow and about control at supersonic speeds were published in a paper before the Deutsche Akademie für Luftfahrtforschung in November 1944.

S-7

"He considers the arrow-wing to be advantageous up to Mach number of 2. He does not know of any supersonic experiments on the subject.

S-8

"Schenbel (Darmstadt) had investigated deformations in high-speed flight.

S-9

"Helmbold at Göttingen suggested boundary [larger layer] suction as a means of stabilizing and locating shock waves. Some study had been made of conditions at the intersection of two shock waves.

S-10

"O. Föppl had used a conical head on a central pipe as a means of producing an inclined shock wave ahead of an air intake at supersonic speed to secure less loss than that occurring in the normal shock wave which would otherwise occur at the entrance."

S-98 Identification No. 494

Technical Intelligence Report No. I-3 May 19, 1945

S-11

This report contains information concerning the Ho 229 airplane, obtained from Eckhardt Kaufmann of the Gotha W. F. Co. No aerodynamic information is contained.

5375-162 Identification No. 565

Technical Intelligence Report No. I-16, May 10, 1945

S-12

A Feuerlilie F-55 missile (described in other reports) was tested at Peenemunde in November 1944 and it tumbled. No further information of aerodynamic interest not already covered in other reports is given.

S-116 Identification No. 623

S-13

This document is a Focke-Wulf report (in German) regarding an advanced single jet fighter design, the "TL-Jäger" with the HeS011 engine. This design appears to be the FW-183 mentioned by Tank in an interrogation (T.I. Rep. No. I-10). It has 40° sweepback, a horizontal tail (with 40° sweepback and 15° dihedral) mounted on a boom well above the jet, which emanates from the fuselage tail. The projected high speed was 620 miles per hour at approximately 23,000 feet.

S-99 Identification No. 493

Technical Intelligence Report No. I-2 (and No. I-2a), May 11, 1945

Interrogation of Dr. H. Wagner

S-14

This report contains a history of Wagner's work in guided missiles, with some details on the Hs 293, 294, 295, 296, 297, 298, 298 V1, and 298 V2.

S-15

Hs 297 has a pitot tube control "arranged to keep the Mach number constant to avoid aerodynamic difficulties at higher speeds. This control operates a simple throttle valve."

S-16

On the Hs 297, "A new control surface developed by Wagner in 1941 was used, giving small and constant hinge moment coefficients over a wide range of Mach number (subsonic). The surface has a small flat plate spoiler at the trailing edge." It was tested at DVL and later in the larger tunnel at Göttingen.

S-112 Identification No. 589

Tsien, H. S.: Reports on the Recent Aeronautical Developments of Several Selected Fields in Germany and Switzerland - Arrow-Wing (Pfeilflügel)

S-17

The report covers the work on "arrow wings" conducted at Göttingen (Betz and Seiferth), DVL, and LFA (Blenk and Zobel). Although the Germans were certainly aware of the advantages of swept wings for high-speed flight, the status of their theoretical knowledge of the subject does not appear to have been as advanced as that evidenced in work in this country (NACA ACR L5G07).

The Germans, however, had done considerable experimental work on their "arrow-wings" (limited to fairly short spans) and had made attempts to apply the principle to propeller and fuselage design.

S-18

The following reports are mentioned and may be of interest:

Koch, G.: "Druckverteilungsmessungen am schiebenden Tragflügel" (Measurements of Pressure Distribution on a Wing in Sideslip) Lilienthal-Geselschaft, Bericht Nr. 156, 1942.

Ludwieg, H.: "Pfeilflügel bei hohen Geschwindigheiten." (Sweptback wings at High Velocities) Lilienthal - Gesselschaft, Bericht Nr. 127,1940

S-18

Quick, A. W.: "Aerodynamische und flugmechanische Fragen der Luftschraubenentwicklung." (Aerodynamic and General Aeronautical Problems of Propeller Development.) Schriften der Deutchen Akademie der Luftfg.

In their tests the following disadvantages of both sweptback and sweptforward wings (brought about by premature tip stalling in the former and premature root stalling in the latter) were disclosed.

S-19

"a. The maximum lift coefficient is smaller due to premature stalling.

b. There is an undesirable shift of the center of pressure near the maximum lift.

c. The roll stability and the directional stability are reduced at high lift coefficients.

d. The aileron effectiveness is reduced at high angles of attack."

6960 - 215 Pt. 2 Identification No. 638

Tsien, H. S.: Reports on the Recent Aeronautical Developments of Several Selected Fields in Germany and Switzerland - Ramjet, Aeropulse, Installation of Turbojets in an Airplane.

S-20

In tests to determine the optimum installation arrangement for turbo-jet units, the AVA at Gottingen used both hot and cold jet simulation in model tests. It was found that heat was unnecessary for investigation of flow characteristics around the turbo-jet, provided

the momentum changes (from inlet to outlet of the duct) are made equal for the cold and the hot jets. Studies involving the wake of the jet (such as studies of tail surface characteristics) must be made with a hot jet. It is pointed out, however, that duplication of mass flows may lead to difficulties.

S-20

Tests were made to determine aerodynamic characteristics of the turbojet duct itself, interference drag of the duct and the wing, influence of the jet on aerodynamic characteristics of an airfoil placed at various positions with respect to the duct, and the effects of duct inlet shape. The report contains a list of references covering these investigations.

S-113 Identification No. 587

Tsien, H. S.: Reports on the Recent Aeronautical Developments of Several Selected Fields in Germany and Switzerland - Boundary Layers and the Interaction of Boundary Layers and Shock Waves in Transonic Flows.

This report contains highlights in the work of J. Ackeret of Zürich Polytechnical University of the interaction of Reynolds number and Mach number, and shows The desirability of Reynolds number duplication in high-speed testing.

S-21

Ackeret found that the "λ-shock formation" (an oblique shock ahead of the main shock) encountered at low Reynolds number in transonic flow disappeared at high Reynolds numbers, with only a single (straight) shock occurring. The boundary layer separation was reduced "due to the absence of the thickening effect of the

first oblique shock. Thus the drag of the airfoil was much smaller at high Reynolds number than at low Reynolds number with the same Mach number."

Ackeret showed that disappearance of the oblique shock at high Reynolds number was due to natural transition of the laminar boundary layer to turbulent boundary layer before reaching the supersonic flow region. He did this by producing a turbulent boundary layer through the use of a small wire at the leading edge and showing no oblique shock formation even at small Reynolds number.

S-21

Tsien mentions the difficulties encountered by the wind tunnel group at Kochel in attempting to measure boundary layer thickness by the schlieren method and their resulting return to the pitot tube method.

~~SECRET~~

S-111 Identification No. 588

Tsien, H. S.: Reports on the Recent Developments of Several Selected Fields in Germany and Switzerland.

Gasdynamics with Supersonic Velocities

S-22

"The main German effort of investigating the supersonic flows seems to be concentrated on the following subjects:

a) Aerodynamic Characteristics of shells and missiles

b) Flow problems in connection with the design of Aeropulse and ram jets at high speeds

c) Detonation or shock waves"

S-23

The reliability of wind-tunnel tests made to determine the aerodynamic characteristics of shells was investigated. In general, the German investigations indicate that the main difficulties of wind-tunnel testing of shells is the effect of wake distortion (due to the reflected bow wave and the presence of model support) and the effect of Reynolds number difference on skin friction and base pressure. The neglect of shell rotation results in a small but definite decrease (in drag rotating causes an increase of about 3.5 percent), possibly because rotation increases the boundary-layer thickness due to centrifugal forces. "The lift also tends to shift to the base of the shell slightly by rotation." (References 1, 2, 3, and 4 cover these subjects.)

S-24

Control and stability of fin-stabilized (winged or wingless) projectiles was "intensively investigated" by the HAP (Heeresanstalt Peenemunde).

~~SECRET~~

". . . The controls were all located at the fin surfaces, the wing surfaces had no ailerons. The two main problems are:

1. To reduce the hinge moment for a given control moment so that smaller and lighter servos can be used;

2. To reduce the variation of the distance between the aerodynamic center and the center of gravity of the missile throughout the working Mach number range so that the control moment necessary for various angles of attack can be kept at a smaller value.

S-24

"To solve the first problem, aerodynamic balance has been tried. However, it was found that to obtain the necessary aerodynamic balance at supersonic speeds, the surface becomes aerodynamically overbalanced for a small range of control surface angle around the neutral position. Then biplane control surfaces were tried. The drag of such surfaces was too high. Furthermore, spoilers were found to be unsatisfactory as their effectiveness at supersonic flight velocities is much smaller than hinged surfaces. The best solution obtained so far was the tandem surfaces as shown in Fig. 1. The desired hinged moment characteristics can be obtained throughout a very wide range of Mach numbers without overbalance.

"The second problem for the winged missile is a rather difficult one. Various shapes of the wing surfaces were tested. The best design is the short tapered plan form as shown in Fig. 2. It was found that for such wing surfaces, the aerodynamic center moves very little for Mach number variations from subsonic to supersonic velocities."

S-25

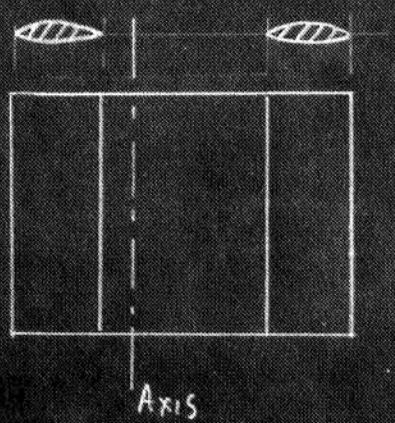


Fig. 1 - Control surface with small hinge moments at all Mach numbers.

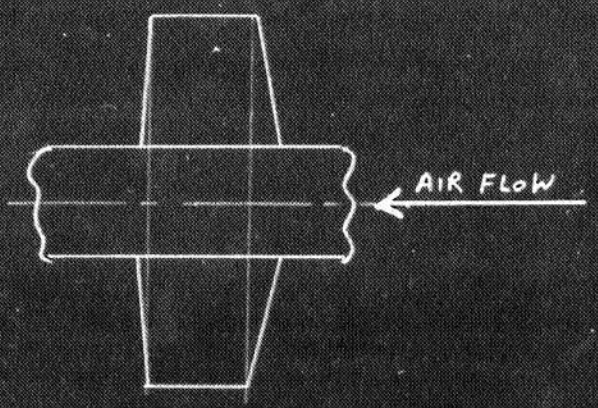


Fig. 2 - Optimum wing design

S-26

In studies of the influence of a hot rocket jet on aerodynamic characteristics of a missile, it was found "that the presence of the jet has a marked influence on the drag of the missile. Due to the suction effect of the jet, the air flow over the tail end of the missile was accelerated and the pressure in this region was thus lowered. Therefore, the drag of the body was increased. At high Mach numbers, however, the presence of the jet eliminated the low pressure wake at the base of the missile and this would decrease the drag. For the particular projectile shape of V-2, it was found that at supersonic velocities the influence on the base drag overbalanced the influence on pressure drag over the downstream part of the body, and the drag was decreased by the jet (Fig. 3).

"The presence of the rocket jet also greatly increased the damping of the missile for yawing oscillations. This effect was measured by mounting the rocket statically but allowed to oscillate. The motion was measured and the damping coefficient deduced. It was found that the increase in damping can be fully explained by the change of angular momentum of the body plus the propellant contained in the tanks. Due to the discharge of the mass, the change of angular momentum contained a term which can be interpreted as the damping moment due to the rocket jet."

S-27

The problem of supersonic flow over shells and missiles was solved to the satisfaction of the Germans by applications of the method of characteristics. (References 5 and 6.)

S-28

"Oscillating Airfoils - The two-dimensional flow over an oscillating airfoil in supersonic flow was linearized (small oscillation and thin airfoil) and completely solved with numerical values of the aerodynamic forces given for free stream Mach numbers up to 5.

S-29

"Interaction of Boundary Layer and Shock Wave - The boundary layer separation due to shock wave gives the forked shock wave. These forked shock waves were calculated and the results given in the form of diagrams. An allied problem is the question of whether it is possible to have a shock wave formed away from the surface of continuous curvature. W. Tollmien has shown by a particular example calculated with the method of characteristics this is possible even in a non-viscous fluid. The pressure distribution over the surface is

S-29

continuous but has a rather sharp rise near the shock. Along the stream lines intersecting the shock wave, the pressure is, of course, discontinuous at the shock. Such investigations will be a great aid in understanding the problem of shock and boundary layer interaction.

S-30

"Chaplygin Method for Two-Dimensional Flow - Guderly has used the asymptotic form of the hypergeometric functions to effect a summation of the infinite series of Chaplygin's solution for the two-dimensional flow over a body in uniform motion."

The report also contains a brief discussion of supersonic tunnel design and the following references regarding the foregoing material:

S-31

(1) O. Walchner, "Systematische Geschossmessungen im Windkanal" Lilienthal - Gesellschaft Bericht Nr. 139 (Teil I), P.29

(2) R. Lehnert, "Systematische Messungen an neun einfachen Geschossformen in Vergleich zu Messungen der AVA Göttingen"
Lilienthal - Gesellschaft Bericht Nr. 139 (Teil II), P.31

(3) R. Lehnert, "Dreikomponentenmessungen am Modell einer 28cm-Sprenggranate fur das Ferngeschutz K5"

(4) E. Hermann, "Dreikomponentenmessungen im Uberschallwindkanal an zwei Flakgranaten und Vergleich mit den Schiessversuchen" Ibid, p.39

(5) W. Tollmien, M. Schafer, "Rotationssymmetrische Uberschallstromungen" Ibid, p.5

(6) G. Guderly, "Erweiterungen der Characteristikenmerhode" Ibid, p.15

(7) Simons, "Untersuchungen an Diffusoren fur Uberschall-Windkanale" Forschungsbericht Nr. 1738 and Nr. 1748/2"

SECRET

6960 Coanda/1 Identification No. 505

S-32 This is a report on interrogation of M. Coanda regarding the development of propulsion devices based upon the "Coanda Effect," as well as applications of the "effect" to rotary pumps, thrust augmentors, superchargers, etc. (Coanda also had ideas for development of a high-lift airfoil using a Coanda slot in the leading edge of the flap.)

S-33 Also included is vague account of a leading-edge slot used on the wing of what Coanda believed was the Me-262. The slot, in profile, opened at a more forward point on the top surface than on the bottom surface, in contrast to the conventional type of slot (such a Handley Page).

6930 Germany/4 Identification No. 619

Technical Intelligence Report No. E-11 18 June 1945

Meteorology - no aerodynamic information

6930 Germany/5 Identification No. 620

Technical Intelligence Report No. E-14 16 May 1945

Meteorology - no aerodynamic information

6930 Germany/6. Identification No. 621

Technical Intelligence Report No. E-15 3 June 1945

Meteorology - no aerodynamic information

SECRET

~~SECRET~~

1001 Horton 229/1 Identification No. 564

Technical Intelligence Report No. I-4 12 May 1945

S-34

This document contains meager information regarding the Horton 229 Bat Wing twin-jet fighter, including photographs of portions of the airplane under construction.

~~SECRET~~

REPORTS

A. High-speed flow

2596 Technical Intelligence Report No. I-38 May 28, 1945

The following reports (in draft or manuscript form) were obtained from Dr. Guderley:

(a) On the Method of Characteristics for Problems of Gas Dynamics.

(b) On the Method of Characteristics for Problems of Interior Ballistics.

(c) On Unsteady Gas Flow in Thin Pipes with Variable Cross-Section.

(d) On a Relation between Incompressible and Subsonic Flows in Two Dimensions

1. Flows at Mach Numbers = ∞
2. Tables of Functions arising with the Method of Characteristics.
3. The Treatment of Compression Shocks.
4. The Flow Near the Pointed Nose of a Body of Revolution.
5. On Asymptotic Presentations of Particular Solutions of the Hodograph Equation for Two Dimmensional Compressible Flows.
6. Solutions Similar to those for Supersonic Steady Flows with Rotational Symmetry.
7. On Unsteady Gas Flows in Thin Pipes with Variable Cross Section.
8. On Disturbances in Sonic and Supersonic Parallel Flow for Two Dimensions and for Rotational Symmetry.

The following reports are available:

1. Eckert, E. and Vietinghoff-Scheel: Report on Flow Through Turbine Lattices. Vorabdruche ans Jalirbuch 1942 der deutschen Luftfahrtforschung (6. Lieferung)

Contains results of interferometer studies (at L.F.A., Braunschweig) and brief theoretical analysis.

2. Zobel, Thes.: Fundamentally New Methods for Improving the Performance of High-Speed Airplanes. Papers of the German Academy for Aeronautical Research. No.144, 1944

Suggestions, based on test results and theory, for improvement in speed (sweptback wings, interference drag clean-up, boundary-layer suction, improvement of fuselage shape for high speed, etc.). Has been translated (by Gersdorff).

3. Ludwieg, H.: Test Results - Sweptback Wings at High Speeds. Lilienthal-Gesellschaft Bericht 127.

Has been translated (by R. V. Hess).

In Lilienthal Gesellschaft Bericht 139:

4. Tollmien, W. and Schafer, M.: Supersonic Flows with Rotational Symmetry.

5. Guderly, G.: Extensions of the Method of Characteristics.

6. Simons, : Investigations on Diffusers for Supersonic Wind Tunnels.

In Lilienthal Gesellschaft Bericht 156:

7. Gothert, B.: Profile Measurements in the DVL High-Speed Wind Tunnel.

8. Zobel, Th.: On Some Results with the Interference Method in the High-Speed Tunnel of the LFA.

9. Gothert, B.: High-Speed Measurements on a Swept-Back Wing ($\varphi = 35^{\circ}$).

10. Koch, G.: Pressure Distribution Measurements on a Yawed Wing.

11. Gothert, B.: Flap (and Elevator) Effectiveness at High Subsonic Speeds (Wind Tunnel Data).

12. Gothert, B.: Spoiler Action at High Subsonic Speeds.

13. Schoppe, G.: Drag Measurements on Cowlings in the High-Speed Tunnel of the LFA.

14. Gothert, B.: High-Speed Measurements on Bodies with Rotational Symmetry and Comparison with Drop Tests.

15. Matt, H.: High-Speed Measurments on Round and Streamline Bars of Different Diameters.

16. Gothert, B.: High-Speed Measurements on a Very Small Wing in the DVL High-Speed Tunnel.

17. Knappe, O.: High-Speed Tunnel Measurements on Profiles and Airplane Models and their Evaluation for Design Purposes.

18. Schulz, G.: Contributions to the Problem of Designing Fast High-Altitude Airplanes.

19. Gothert, B.: Downwash at High Subsonic Speeds.

20. Lindemann, H. Measurements of Longitudinal Stability at High Subsonic Speeds.

21. Naumann, A.: On the Determination of the Critical Mach Number.

22. Helmbold, H. B.: Physical Phenomena in Compressible Subsonic Flow (After Experiments on a Symmetric Profile).

B. Propeller Research

1. Quick, A. W.: Investigations on Propellers with Swept-Back Blade Axis. Lilienthal-Gesellschaft Bericht 156.

2. Quick, A. W.: Aerodynamic and General Aeronautical Problems of Propeller Development. Papers of the German Academy for Aeronautical Research.

This contains discussion of the use of sweptback and sweptforward blades and also a discussion regarding the relative merrits of propeller and turbo-jet propulsion.

3. Kruger, W.: On Wind-Tunnel Tests and Computations Concerning the Problem of Propeller Cowlings. ZWB Forschungbericht. Nr. 1949.

Theory and test results (Gottingen) on hooded propellers.

4. Kramer, Karl N.: On Approximate Computations for Propellers by Means of polars. Jahrbuch 1941 dur dentschen Luftfalntforschung (1404 - 1418)

5. "On the Determination of Terminology for Propellers." Heft 1 der Bauvorschriefften fur Luftschrauben, Ausgabe Januar 1940

C. Jet and Rocket Development

1. Papers of the German Academy for Aeronautical Research. No. 32, 1941 (Jet Propulsion).

2. Neugebauer, Franz: Comparative Evaluation of Propulsion Units on the Basis of Joint Consideration of Airframe and Propulsion Unit. Papers of the German Academy for Aeronautical Research. No. 93, 1944.

Deals with the development of a method for evaluating the qualifications of various propulsion units from the performance viewpoint.

3. Sanger, E. and Bredt, L.: On a Lorin Propulsion Unit for a Jet Fighter. V. and M. No. 3509 (ZWB), 1943.

This article deals with the characteristics, tests, and applications of the propulsion unit. The tests were made in flight and also on an automobile.

4. Wagner, H.: Application of Rocket Propulsion to Gliding Bombs. Papers of the German Academy for Aeronautical Research (Rocket Propulsion), 1943.

5. Lippisch, A.: The Influence of the Propulsion Unit on Aircraft Design. Papers of the German Academy for Aeronautical Research (Rocket Propulsion), 1943 (No. 82).

Contains general performance calculations.

D. Missiles

1. Ludwieg, H. and Weber, E.: On the Influence of a Sweptback Tail on the Drag and the Center-of-Pressure Location of a Long Projectile Stabilized by Tail Surfaces. U. and M. No. 3146, 1944.

Contains theory and test results (Mach no. 2 to 4)

In Lilienthal-Gesellschaft Bericht 139:

2. Walchner, O. : Systematic Wind-Tunnel Tests of Projectiles .

3. Lehnert, R. : Systematic Tests of Nine Simple Projectile Forms Compared with Tests at the AVA, Gottingen.

4. Lehnert, R.: Three-Component Measurements on a Model of a 28-cm. Explosion Grenade for the Long-Range Gun K-5.

5. Hermann, E.: Three-Component Measurements in the Supersonic Wind Tunnel of Two Flak Grenades and Comparison with Actual Firing Tests.